



## Project Introduction

The National Robotics Initiative (NRI) is a cross-governmental, joint solicitation, to keep the US competitive in the field of robotics and to accelerate the development of next-generation robots to keep the U.S. at the leading edge, with participant agencies sharing the results of all research.

## Anticipated Benefits

Benefits to NASA Funded Missions: IHMC: Toward Humanoid Avatar Robots. The Robot Operating System (ROS) software, updated under the Open Source Robotics Foundation (OSRF) grant, was used as the OS for controlling Robonaut 2's legs. The flight certified legs, which were delivered to ISS in early 2014, will be attached by the astronauts during several scheduled Robonaut upgrade sessions between July and August 2014. The IHMC walking software has become the baseline for the R5/Valkyrie robots walking, which will be used as part of the joint Centennial Challenges/HRS Space Robotics Challenge Benefits to NASA Unfunded & Planned Missions IHMC: Toward Humanoid Avatar Robots: walking software through this NRI Grant is being applied to walking humanoid robots. Current Human Mars architectures are showing that infrastructure for these human missions will be in place prior to launching humans. Within these architectures, robotic systems will set up infrastructure and serve as caretakers while waiting for crew. Clemson University: Long, Thin Continuum Robots for Space Applications. Long, thin robotic systems have significant applicability towards inspection for both IVA (ISS) and EVA (ISS and exploration in transit to Mars). MIT: A Novel Powered Leg Prosthesis Simulator for Sensing & Control Development; The lower body exoskeleton developed within this project is potentially applicable to augmenting future exploration suits that will provide crew additional endurance on the Martian surface. University of Texas: Whole-Body Telemanipulation of the Dreamer Humanoid Robot on Rough Terrains Using a Hand Exoskeleton; The whole body control aspects of this grant are applicable to controlling both existing and further Humanoid robots, including Robonaut and R5/Valkyrie. Carnegie Mellon: Symbiotic Exploration; The grant explores multi-robot exploration on planetary surfaces. It potentially has applicability to future human or robotic missions when exploring as pairs, possibly using small rovers as scouts ahead of crew rovers on the Mars surface. MIT: Exosuit System Design Parameters as Revealed by an Integrated, Human Musculoskeletal Computational Model; The exosuit grant has direct applicability to future exploration space suit by adding capability to augment crew performance. Northwestern University: Integrating Physics Models and Control Methodologies for Enhanced Legged Locomotion on Yielding Terrain; This legged motion grant explores the physics behind legged mobility in soft soils. This work is applicable to humanoid robots that will perform infrastructure setup, maintenance and caretaking on the surface of Mars ahead of crew. Benefits to Other Government Agencies: IHMC: Toward Humanoid Avatar Robots: The walking algorithms developed under the grant



National Robotics Initiative

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## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Center / Facility:

Johnson Space Center (JSC)

### Responsible Program:

Game Changing Development

## National Robotics Initiative (NRI)

Completed Technology Project (2012 - 2018)



to the IHMC are being used to provide walking capability in NASA's R5 robot, developed for the DARPA Robotics Challenge (DRC), which will benefit DARPA as well. The interfaces and controls being developed under the Humanoid Avatar Robots for Co-Exploration of Hazardous Environments have the potential to lay the ground work for human controllers to be able to control humanoid robots for use in hazardous environments such as fire control, search and rescue, and disaster response, which would benefit multiple government agencies and entities. In addition, due to the agreement under the NRI, all R&D performed under any of the funding agencies (currently consisting of NASA, the NSF, the NIH, and the USDA) will be shared across agencies. So the NSF and NIH will have access to new robotics technologies for science and medical applications and the USDA will have access to the for application to robotic agriculture applications. MIT: A Novel Powered Leg Prosthesis Simulator for Sensing & Control Development and Integrating Physics Models and Control Methodologies for Enhanced Legged Locomotion on Yielding Terrain; The lower body exoskeleton technology developed through this work has potential applicability to rehabilitation within the DoD (Veteran's administration) or to augment soldier capability. Benefits to the Commercial Space Industry: Long-Range Prediction of Non-Geometric Terrain Hazards for Reliable Planetary Rover Traverse could provide means for future Mars or Lunar rovers to detect soft soil hazards before they enter an area, thereby preventing the loss of an expensive vehicle that could otherwise be mired. Benefits to the Nation: These grants provide R&D funds to U.S. universities and labs to advance different aspects of robotics within the U.S., which will help achieve the president's goal of creating new markets in the U.S. for robots assisting humans. In addition, many of the robotic technologies being matured under these grants could help save lives when applied in the use of robots for search and rescue, use of robots as health monitoring assistants, or through robotic applications in surgery, once the technology has fully matured.

## Project Management

**Program Director:**

Mary J Werkheiser

**Program Manager:**

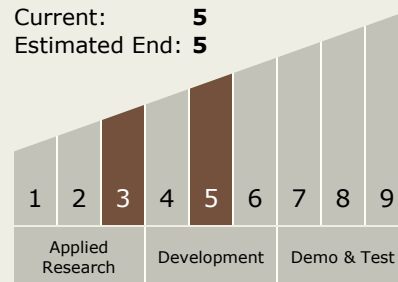
Gary F Meyering

**Principal Investigator:**

William J Bluethmann

## Technology Maturity (TRL)

Start: **3**  
 Current: **5**  
 Estimated End: **5**

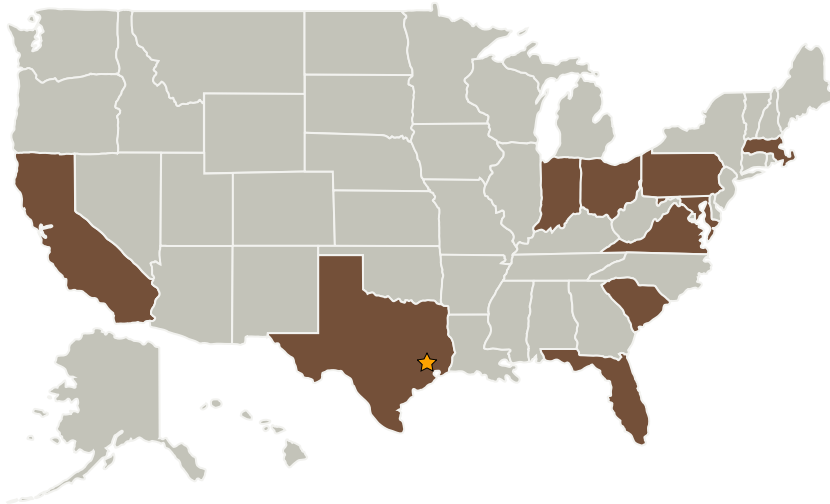


## Target Destinations

The Moon, Mars, Earth



## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations	
California	Florida
Indiana	Maryland
Massachusetts	Ohio
Pennsylvania	South Carolina
Texas	Virginia

## Project Transitions

 **September 2012:** Project Start

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✓ **June 2018:** Closed out

**Closeout Summary:** The NRI is a cross-governmental agency, joint solicitation, which supports a national initiative to accelerate the development of next-generation robots in the U.S. NASA supported 11 research grants developing cutting edge robotic technologies several of which are being infused into current NASA projects. Through prefunded work and no cost extensions some of this work is continuing into FY18.

### Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>